RESEARCH POTENTIAL OF DAN FOR STUDIES OF HYDROGEN AND OH/H_2O BEARING MINERALS IN THE MARTIAN SOIL. I.G.Mitrofanov[1] (imitrofa@space.ru), M.L.Litvak[1], O.Aharonson[2], W.V.Boynton[3], D.M.Drake[4], J.B.Garvin[5], A.S.Kozyrev[1], S.Kulkarni[2], M.L.Litvak[1], A.Malakhov[1], J.Moersch[6], I.Mokrousov[1], R.Z.Sagdeev[7], A.B.Sanin[1], R.S.Saunders[8], V.V.Shevchenko[9], S.Squyres[10], J.Trombka[5], V.I.Tret'yakov[1] and A.Vostrukhin[1], [1]Institute for Space Research, Russia; [2]CalTech, USA; [3]University of Arizona, Tucson, USA; [4]TechSouce, Sanra Fe, USA; [5]Goddard Space Flight Center, Greenbelt, USA; [6]University of Tenessee, USA; [7]University of Maryland, Collage Park, USA; [8]NASA HQ, Washington, DC, USA; [9]Shternmerg Astronomical Institute of Moscow State University, Russia; [10]Cornell University, USA.

Introduction: It is known that high energy neutrons are moderated down to thermal energy efficiently by collision with hydrogen, because the protons, the nuclei of hydrogen atoms, absorb a large fraction of the neutron energy in each collision. Neutron activation is often used to estimate the moisture of soil down to 1-2 (better to say up to 1 m) meters depth. The investigation Dynamic Albedo of Neutrons (DAN) [1] with a pulsing neutron generator PNG, which irradiates the soil with high energy neutrons and produces a secondary emission of moderated and delayed neutrons, may allow study of the distribution of hydrogen or water at the surface of Mars along the path of the MSL rover.

Numerical modeling of DAN: Numerical simulations of the DAN investigation were performed using standard MCNPX code [2]. Emission of moderated neutrons is shown to continue as long as 10 msec after an individual pulse of PNG, with a flux decrease of about 10^4 times during this time (Figure 1). For a pulsing frequency 10 Hz, the phase of active measurements is <10% of the pulse period, and background measurements correspond to the complementary fraction of >90% of the pulse period.

Time profiles of induced albedo emission depend on the content of Hydrogen in the soil (Pathfinder composition [3] was used for the calculation). Figure 1 presents results for thermal neutron emission for soil with water content from 0.045 wt% (equivalent to 50 ppm of H) up to 10 wt%. The amplitude of the die-away time profile increases by about a factor of 10 as the water content increases from 0.045 wt% up to 10 wt%, and the duration of the d-e away profile increases by several times with increasing water content.

The method of neutron activation is also very sensitive for detection of layering of H bearing minerals in the subsurface. Diffusion and moderation of neutrons in different layers is associated with different time profiles of die-away for thermal neutrons. If dry soil lies at the top with wet soil beneath, the early time profile following the pulses is close to the profile for dry soil, and the time profile at the late stage is contributed mainly by the bottom layer with the larger content of water (see Figure 2).

Conclusions: During surface operations of MSL DAN measurements will allow estimation of the presence of hydrogen from 0.1 wt% of water equivalent and will resolve near-surface layering of hydrogen bearing minerals.

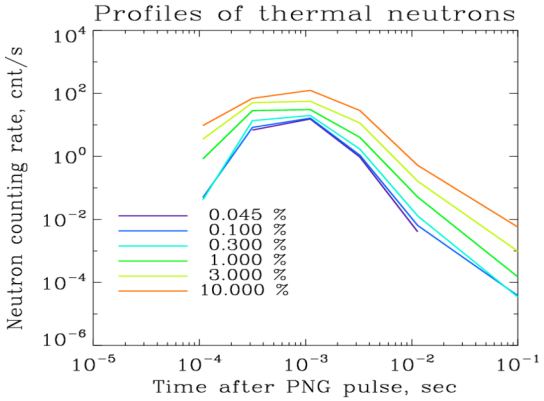

Figure 1: Numerical simulation of die-away time profiles of thermal neutrons, induced in Martian soil by DAN neutron generator (different curves correspond to different weight % of water).

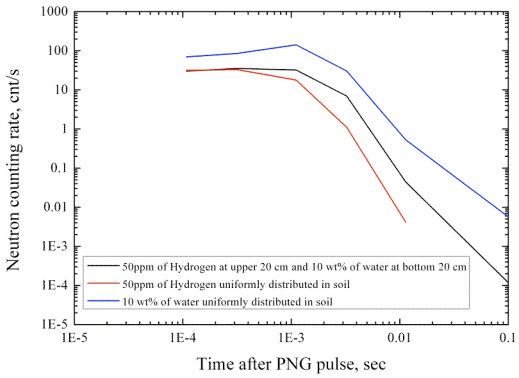

Figure 2: Dependence of die-away curve of thermal neutrons on layering structure of subsurface soil.

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References: [1] Mitrofanov et al., Abstract for this workshop (2006). [2] Waters, L.S., MCNPX User's Guide (document LA-UR-99-6058) Los Alamos National Laboratory (1999). [3] Foley, C. N., Economou, T., Clayton, R. N. Final chemical results from the Mars Pathfinder alpha proton X-ray spectrometer. Geophys. Res. DOI DOI 10.1029/2002JE002019 (2003).